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The Spruce Beetle

Edward H. Holsten,[1] R.W. Thier,[2] and J.M. Schmid[3]

Figure 1—*Yellowish orange and reddish colors in the tops of trees are evidence of spruce beetle infestation in Arizona.*

The spruce beetle, *Dendroctonus rufipennis* (Kirby), is the most significant natural mortality agent of mature spruce. Outbreaks of this beetle have caused extensive spruce mortality from Alaska to Arizona and have occurred in every forest with substantial spruce stands. Spruce beetle damage results in the loss of 333 to 500 million board feet of spruce sawtimber annually. In the past 25 years, outbreaks have resulted in estimated losses of more than 25 million board feet in Montana, 31 million in Idaho, over 100 million in Arizona, 2 billion in Alaska, and 3 billion in British Columbia (fig. 1).

Spruce beetle outbreaks cause extensive tree mortality and modify stand structure by reducing the aver-

[1]Entomologist, U.S. Department of Agriculture, Forest Service, Alaska Region, Anchorage, AK.
[2]Entomologist, U.S. Department of Agriculture, Forest Service, Intermountain Region, Boise, ID.
[3]Entomologist, U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

age tree diameter, height, and stand density, leaving small, slow-growing trees and intermediate-sized trees to become dominant.

As mature spruce are killed, forage may increase, benefiting some wildlife species. But species that depend on the mature spruce for habitat may be adversely affected.

Indirectly, extensive spruce mortality can also affect water yields and result in water gains in rivers, lakes, and streams because of reduced transpiration from dead and dying trees.

Hosts

The spruce beetle infests all species of spruce within its geographical range (fig. 2). The more important commercial tree species attacked include white, Lutz, Sitka, and Engelmann spruce.

Evidence of Infestation

On standing trees, the first sign of spruce beetle infestation is reddish-brown boring dust accumulating at the beetle's entrance holes, in bark crevices, and on the ground around the trunk of infested trees. Masses of pitch may accumulate around the en-

Figure 2—*The geographic range of the spruce beetle.*

trance sites. These signs are most visible the summer following infestation and become less noticeable months later.

On windthrown trees and logging residuals, spruce beetle attacks are readily detected on the lower surfaces of the material and should not be confused with *Ips* beetle attacks more commonly found on the upper surfaces.

Some standing trees may be attacked on only one side of the bole, creating a "strip attack." The infested area may die, but the tree usually remains alive, so the foliage does not discolor. Trees with "strip attacks" frequently are infested by subsequent spruce beetle generations and may host two or more generations simultaneously.

During the first fall and winter following spruce beetle infestation, one should look for trees "debarked" by woodpeckers (fig. 3). Partially debarked, green trees are easily noticed. However, on trees without significant debarking, one must be relatively close to see sawdust in bark crevices and around the tree base.

The needles of infested trees do not usually fade or discolor within the first year following attack. However, during the second summer following attack most needles turn yellowish. Some needles even remain green until the third summer, or up to 2 years after the initial infestation. The needles on separate branches of the same tree discolor at different times. Needles are removed periodically from the trees by wind or thunderstorms, leaving the upper crowns of exposed twigs with a yellowish-orange to reddish hue.

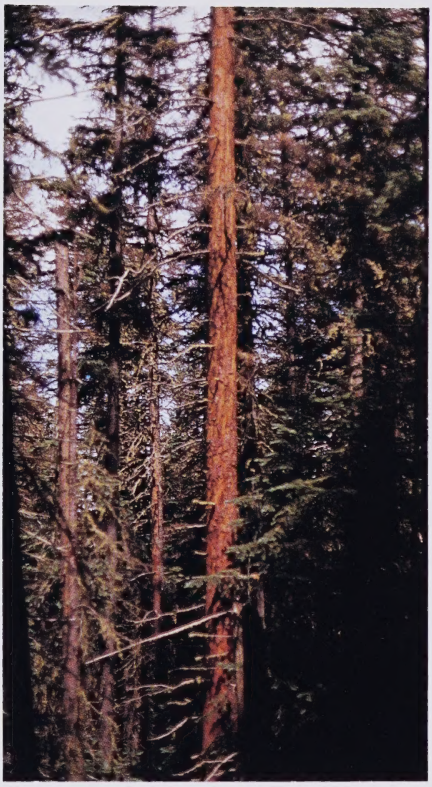

Figure 3—*Infested spruce debarked by woodpeckers.*

Identification of the Life Stages

Adult beetles are blackish brown to black with reddish-brown or black wing covers. The beetles are cylindrical, approximately 1/4 inch (6 mm) long and 1/8 inch (3 mm) wide (fig. 4).

Spruce beetles look similar to other *Dendroctonus* beetles and, if no host material is present, can be distinguished from them only by microscopic examination. At first glance, spruce beetles may also be confused with *Ips* beetles in spruce. It is important to remember that the posterior margins of the wing covers on spruce beetles are evenly rounded, while *Ips* beetles have wing covers with concave margins and teethlike projections.

Figure 4—*An adult spruce beetle.*

The eggs of the spruce beetle are oblong, pearly white, and 1/16-inch (1.5 mm) long. The larvae are stout, cylindrical, legless grubs that pass through 4 larval stages (instars) and reach a length of 1/4 inch (6 mm) at maturity (fig. 5). The pupae are opaque white, inactive, and somewhat similar in size and shape to adults.

Life Cycle

Spruce beetles may complete their life cycle in 1 year on warm sites at lower elevations or take up to 3 years on cool, well-shaded locations on north slopes.

However, it generally requires 2 years for the spruce beetle to complete its life cycle. Adults may emerge any time from May to October, depending on temperature. The beetles attack host material soon after emerging. Adults that appear in August to October may represent a reemergence of parent adults or a movement of maturing brood adults to hibernation sites.

Figure 5—*Spruce beetle larvae.*

Figure 6—*Spruce beetle egg gallery and larval mines.*

To deposit eggs, female beetles bore through the outer bark of the host tree and create egg galleries in the underlying phloem tissue. Eggs are laid on either side of the egg gallery (fig. 6). Egg galleries are slightly wider than the beetle and, except for the terminal portion, are packed with frass and boring dust. Egg gallery length ranges from about 2.5 to 12 inches (6 to 30 cm). Eggs are usually deposited in short rows along alternate sides of the gallery in numbers ranging from 4 to 14 eggs per centimeter of gallery.

Most of the eggs hatch by August. The larvae bore outward from the egg gallery and feed as a group for the first and second instars. Third and fourth instars construct individual feeding galleries. The larval stage predominates during the first winter, although adults and eggs may also be present. During the 2-year life cycle, most larvae pupate approximately 1 year after attack. Pupation lasts 10 to 15 days and usually takes place in pupal chambers at the end of the larval galleries.

During the second winter of the 2-year cycle in standing trees, some beetles overwinter in their pupal sites. Other beetles—from 5 to 88 percent—emerge, move to the base of the tree, and bore into the bark near the litter line to hibernate. In windthrown trees, most adults overwinter in place. Approximately 2 years after attack, adults emerge from overwintering sites and attack new host material.

Stand Conditions Conducive to Infestations

Endemic spruce beetle populations usually live in windthrown trees (fig. 7). When beetle populations increase to high levels in downed trees, beetles may enter susceptible, large-diameter, standing timber. Most outbreaks in standing timber originate in windthrown trees.

In mature stands, large-diameter trees ($\geq 18''$) usually are attacked first, an obvious characteristic denoting susceptibility to spruce beetle attack. If an infestation persists in a stand, smaller diameter trees are attacked. Recent evidence from Alaska indicates that tree diameter is important in determining susceptibility only when coupled with less-than-average radial growth in the preceding 5 years. The proximity of uninfested standing spruce trees to infested hosts also denotes vulnerability to attack.

In the Rocky Mountain area, susceptibility of a stand to spruce beetle attack is based on the physiographic location, tree diameter, basal area, and percentage of spruce in the canopy. Spruce stands are highly susceptible if they grow on well-drained sites in creek bottoms, have an average diameter (d.b.h.) of 16 inches or more, have a basal area greater than 150 square feet per acre, and have more than 65 percent spruce in the canopy.

In Alaska, the susceptibility of a spruce stand is based on average tree

Figure 7—*Windthrown trees and logging residuals—prime habitat for beetle populations.*

diameter, age of the stand, condition of the stand, and proportion of white spruce in the canopy. A spruce stand of old-growth or damaged sawtimber is very susceptible to spruce beetle attack if the larger diameter spruce trees have a slower-than-average growth rate, have an average diameter (d.b.h.) greater than 12 inches, and if the stand has more than 70 percent white spruce.

Susceptibility of a spruce stand to spruce beetle attack in British Columbia and the Northeastern United States is based on criteria similar to that used in the Rocky Mountains and Alaska.

Hazard rating systems based on the stand and site conditions discussed above have been developed so that managers can identify stand susceptibility to spruce beetle attack.

Management Strategies

Forest managers can develop various strategies to avoid or reduce resource losses to spruce beetles. Before developing a strategy, the forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered because population levels will determine the priority of management actions and the type of strategy to be invoked.

The primary strategy should be silvicultural treatments of potentially susceptible stands in order to maintain their health with a moderate growth rate. The first step in this strategy is to hazard-rate spruce stands, which will indicate the most susceptible stands. The stands can then be treated with harvesting directed at the most susceptible stands. Infested logging residuals need never become a significant contributor to spruce beetle populations if stump height is kept below 18 inches (45 cm) and cull logs and tops are limbed, cut into short lengths, and left unshaded, unpiled, and exposed to sunlight. Silvicultural treatments have greater long-term effectiveness, because these treatments modify stand conditions.

The primary strategy assumes, in general, beetle populations are not immediately threatening resource values. If beetle populations are threatening, then strategies involving suppression methods are more appropriate. Suppression methods including silvicultural, physical, and chemical measures are available to forest managers for reducing spruce beetle populations. Some methods are suitable only for populations in windthrown host material; other methods are better suited for infestations in standing trees. Most suppression methods are short-term responses to existing beetle populations and, therefore, correct only the immediate situation.

Figure 8—*Green trees felled to capture emerging spruce beetles.*

Silvicultural Methods:

- ***Sanitation overstory removal*** involves the removal of all infested and susceptible spruce to encourage regeneration of a new vigorous stand.

- ***Sanitation partial*** cut involves the removal of infested and susceptible spruce to improve the growth of the residual stand. Sanitation partial cut removes most of the larger trees but may leave a residual stand that is below the recommended level of basal area. This residual stand may be more susceptible to windthrow.

- ***Trap trees*** are green trees with a diameter greater than 18 inches (d.b.h.) that are felled before beetle flight. Trap trees can absorb up to 10 times the number of spruce beetles that a standing tree will absorb. Once infested, trap trees should be removed from the forest.

Trap trees shaded from direct sunlight attract the most beetles. Spruce beetles attack cool, shaded portions of the trap tree boles (fig. 8). Felled trees should not be delimbed because limbs on the upper side of the bole provide shade while limbs on the underside permit the beetles to colonize the underside of the bole by keeping it off the ground.

Past ratios of trap trees to infested standing trees have ranged from 1:2 to 1:10. Current ratios vary with the size of the green trees to be felled as traps, with the number and size of infested trees in a stand, and with the existing beetle population.

- ***Lethal trap trees*** are green trees injected with a silvicide and felled before beetle flight. They are effective in areas where traps cannot be removed.

Physical Methods:

- ***Solar heat*** involves exposing infested logging residuals or windthrow to direct sunlight to kill inhabiting larvae. To maximize brood mortality, residuals should be cut into 5-foot lengths. All branches and debris shading the host material should be removed. The infested material should be rotated at 2-week intervals during the summer to expose all surfaces. While using solar heat is effective in the Rocky Mountains, it is not effective in Alaska, because summer temperatures are not warm enough.

- ***Fire*** involves piling and burning infested logging residuals and windthrow to destroy inhabiting broods. The infested material is usually green and difficult to burn, but only the bark has to be scorched to destroy the inhabiting brood.

Chemical Methods:

- ***Pheromones*** are chemical substances that influence insect behavior. Synthetic aggregating and anti-aggregating pheromones increase the attractiveness of trap trees, attract beetles into the trees to be cut, or discourage infestation of high-value trees. Aggregating pheromones are most efficient when used with trap trees. Methylcyclohexenone (MCH), an anti-aggregating pheromone, shows promise in discouraging spruce beetles from attacking trees; however, it has not yet been registered by the U.S. Environmental Protection Agency (EPA).
- ***Insecticides***, such as Lindane and carbaryl, can be applied to the boles of uninfested trees to kill attacking adults. In Alaska, carbaryl applied as a 2-percent spray has provided 100-percent protection from attacking beetles for at least 2 years. Cacodylic acid and MSMA (monosodium methanearsonate) are silvicides that can be injected into standing trees, which become lethal trap trees when they are felled.

Assistance

More information about the management of the spruce beetle may be obtained from the State Forester's office or the U.S. Department of Agriculture, Forest Service, Forest Pest Management.

The publications listed in the references provide more information on the biology, ecology, and management of the spruce beetle.

References

Alexander, R.R. 1986. Silvicultural systems and cutting methods for old-growth spruce–fir forests in the central and southern Rocky Mountains. Gen. Tech. Rep. RM–126. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 33 p.

British Columbia Ministry of Forests. 1981. Spruce beetle management seminar and workshop. In: Proceedings, 1980 seminar and workshop; 1980 October 7–8; Prince George, B.C. Pest Mgmt. Rep. No. 1, Victoria, B.C., Canada: Province of British Columbia, Ministry of Forests. 16 p.

Gibson, K.E. 1984. Use of trap trees for the reduction of spruce beetle-caused mortality in old-growth Engelmann spruce stands in the Northern Region. Rep. No. 84–10. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region. 11 p.

Hard, J.S.; Holsten, E.H. 1985. Managing white and Lutz spruce stands in south-central Alaska for increased resistance to spruce beetle. Gen. Tech. Rep. PNW–188. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 21 p.

Hard, J.S.; Werner, R.A.; Holsten, E.H. 1983. Susceptibility of white spruce to attack by spruce beetles during the early years of an outbreak in Alaska. Canadian Journal of Forest Research 13:678–684.

Hodgkinson, R.S. 1985. Use of trap trees for spruce beetle management in British Columbia: 1979–1984. Pest Mgmt. Rep. No. 5. Victoria, B.C., Canada: Province of British Columbia, Ministry of Forests. 39 p.

Holsten, E.H.; Wolfe, R.L. 1979. Spruce beetle risk rating system for white spruce on the Kenai Peninsula. Tech. Rep. R10–11. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. 21 p.

Holsten, E.H. 1990. Spruce beetle activity in Alaska: 1920–1989. Tech. Rep. R10–90–18. Anchorage, AK: U.S. Department of Agriculture, Forest Service, Alaska Region. 28 p.

Massey, C.L.; Wygant, N.D. 1954. Biology and control of the Engelmann spruce beetle in Colorado. Agric. Cir. No. 944. Washington, DC: U.S. Department of Agriculture. 35 p.

Schmid, J.M.; Frye, R.H. 1976. Stand ratings for spruce beetles. Res. Note RM–309. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p.

Schmid, J.M.; Frye, R.H. 1977. Spruce beetle in the Rockies. Gen. Tech. Rep. RM–49. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 38 p.

Werner, R.A.; Baker, B.H.; Rush, P.A. 1977. The spruce beetle in white spruce forests of Alaska. Gen. Tech. Rep. PNW–61. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 13 p.

Werner, R.A.; Hastings, F.L.; Holsten, E.H.; Jones, A.S. 1986. Carbaryl and lindane protect white spruce from attack by spruce beetles (Coleoptera: Scolytidae) for three growing seasons. Journal of Economic Entomology 79:1121–1124.

Werner, R.A.; Holsten, E.H. 1983. Mortality of white spruce during a spruce beetle outbreak on the Kenai Peninsula in Alaska. Canadian Journal of Forest Research 13:96–101.

Wood, S.L. 1963. A revision of the bark beetle genus *Dendroctonus* Erichson (Coleoptera: Scolytidae). The Great Basin Naturalist 23:1–117.

Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.